REPORT OF SURVEY CONDUCTED AT

THERMACORE, INC.
LANCASTER, PA

July 1997

Best Manufacturing Practices

BEST MANUFACTURING PRACTICES CENTER OF EXCELLENCE
College Park, Maryland
www.bmpcoe.org

Foreword

This report was produced by the Best Manufacturing Practices (BMP) program, a unique industry and government cooperative technology transfer effort that improves the competitiveness of America's industrial base both here and abroad. Our main goal at BMP is to increase the quality, reliability, and maintainability of goods produced by American firms. The primary objective toward this goal is simple: to identify best practices, document them, and then encourage industry and government to share information about them.

The BMP program set out in 1985 to help businesses by identifying, researching, and promoting exceptional manufacturing practices, methods, and procedures in design, test, production, facilities, logistics, and management – all areas which are highlighted in the Department of Defense's 4245-7.M, *Transition from Development to Production* manual. By fostering the sharing of information across industry lines, BMP has become a resource in helping companies identify their weak areas and examine how other companies have improved similar situations. This sharing of ideas allows companies to learn from others' attempts and to avoid costly and time-consuming duplication.

BMP identifies and documents best practices by conducting in-depth, voluntary surveys such as this one at Thermacore, Inc., Lancaster, Pennsylvania conducted during the week of July 14, 1997. Teams of BMP experts work hand-in-hand on-site with the company to examine existing practices, uncover best practices, and identify areas for even better practices.

The final survey report, which details the findings, is distributed electronically and in hard copy to thousands of representatives from government, industry, and academia throughout the U.S. and Canada – *so the knowledge can be shared.* BMP also distributes this information through several interactive services which include CD-ROMs, BMPnet, and a World Wide Web Home Page located on the Internet at http://www.bmpcoe.org. The actual exchange of detailed data is between companies at their discretion.

Thermacore's success demonstrates how a small, high tech, U.S. company can be an effective global competitor by maintaining a strong emphasis on technology, and applying it to meet market-driven needs. From the outgrowth of more than 30 years of engineering development, Thermacore created a superior product which surpassed other available options in the marketplace. This solid technology base is the cornerstone and foundation of Thermacore's competitive edge. Among the best examples were Thermacore's accomplishments in heat pipe wick structure; material tracking high volume line; and international competitiveness.

The Best Manufacturing Practices program is committed to strengthening the U.S. industrial base. Survey findings in reports such as this one on Thermacore expand BMP's contribution toward its goal of a stronger, more competitive, globally-minded, and environmentally-conscious American industrial program.

I encourage your participation and use of this unique resource.

Ernie Renner
Director, Best Manufacturing Practices

Contents
Thermacore, Inc.

C o n t e n t s (Continued)

Thermacore, Inc.

Figure
Thermacore, Inc.

Section 1

Report Summary

Background

Thermacore, Inc. began as an engineering development company in 1970. Its founders pursued new developments in heat pipe technology by addressing various temperature regimes, envelope materials, and fluid media. During the 1980s, grants and contracts enabled Thermacore to commercialize its technology. By the end of the decade, the company began developing designs using copper tubes and sintered copper powder wicks that provided thermal power dissipation characteristics an order of magnitude beyond those achieved by earlier designs. In the early 1990s, Thermacore developed a manufacturing base, but continued to maintain a strong research and development emphasis. Today, the company is a world leader in heat pipe technology.

Besides its manufacturing operations, Thermacore provides expertise on state-of-the-art heat pipe technology and real-world solutions for practical thermal management to its customers. The company's two most notable examples are a Thermacore heat pipe for Pratt & Whitney which can transport more than 100,000 watts per square centimeter; and a Thermacore porous metal heat exchanger for the Department of Energy which can exceed 4,000 watts per square centimeter using helium. Both solutions are believed to be world records. Thermacore has also built heat pipes and systems that range from liquid oxygen for cryogenic temperatures to molten silver for operation in excess of 2,000°C.

Thermacore, a subsidiary of DTX Corporation, is located in Lancaster, Pennsylvania. The company encompasses 56,000 square feet of building area, employs 115 personnel, and achieved $13 million in revenues in 1997. Applications for Thermacore's products include notebook computers; desktop computers; workstations; power electronics; telecommunications; mold cooling; and heat exchangers. Among the best practices documented were Thermacore's heat pipe wick structure; material tracking high volume line; and international competitiveness.

Selecting the proper wick structure based on the application is an important design aspect. Thermacore has determined that sintered powder metal is the optimum wick structure for cooling electronic components in computer products (e.g., notebooks, laptops, desktops, high-end servers). This exclusive wick structure enables heat pipes to operate effectively in any orientation, and permits them to be bent into various heat sink shapes without any significant reduction in performance.

Thermacore developed a disciplined process for tracking in-process work, scrap rates, and finished products on its high volume manufacturing lines. This material tracking high volume line system can handle controlled quantities, evaluate performance throughout the manufacturing process, trace problems to a root cause, and ensure that Thermacore's customers always receive defect-free products. Since implementing the system, Thermacore has reduced its scrap rate from 30% to less than 1%.

From the start of its great production surge, Thermacore was an international competitor. Intel Corporation recognized the superior thermal performance of Thermacore's sintered powder metal wick technology and designs, and passed this information on to its customers. As a result, computer manufacturers all over the world became greatly interested in Thermacore's products for Pentium chip cooling applications. Thermacore has steadily been taking market share from its competitors, and has now captured more than half of the heat pipe market in Taiwan, where more than 40% of the world's laptop computers are manufactured.

Thermacore's success demonstrates how a small, high tech, U.S. company can be an effective global competitor by maintaining a strong emphasis on technology, and applying it to meet market-driven needs. From the outgrowth of more than 30 years of engineering development, Thermacore created a superior product which surpassed other available options in the marketplace. This solid technology base is the cornerstone and foundation of Thermacore's competitive edge. The BMP survey team considers the following practices to be among the best in industry and government.

Best Practices

The following best practices were documented at Thermacore:

Information

The following information items were documented at Thermacore:

Item	Page
Forward Thinking Manufacturing	**11**

Recent interest in the marketplace has encouraged Thermacore to apply forward thinking techniques to its manufacturing operations. The company is now focusing on quick responses to market demands, and striving to improve quality and reduce cost. A master plan has also been developed which enables the company to maintain its flexibility and meet its internal growth goals.

Family Atmosphere	**11**

Thermacore's basic approach to maintaining a family atmosphere is to keep the work environment informal, and eliminate potential barriers between employees. The company has adopted various practices which support and encourage this approach. The overall attitude in the facility is one of sharing, caring, and smiling.

Item	Page
Sales Forecasting	**12**

Thermacore has developed a sales forecasting system to manage its business and production processes. By breaking its sales into product areas, Thermacore identifies its current and potential heat pipe customers for each area. Thermacore also uses yearly, monthly, and weekly charts to determine which projects are critical for its future business success.

Point of Contact

For further information on items in this report, please contact:

Mr. Jon Buesking
Thermacore, Inc.
780 Eden Road
Lancaster, Pennsylvania 17601
(717) 569-6551
FAX: (717) 569-4797
E-mail: buesk@thermacore.com

Section 2

Best Practices

Design

Customer Interface

Thermacore, Inc. considers customer interface to be an important key to the company's future and the advancement of heat pipe technology. Since heat pipe technology is a highly-specialized field and relatively unknown as a cooling tool, Thermacore typically approaches potential customers through their engineers. By interacting with the engineers, Thermacore builds custom-designed, heat pipe products that meet the customer's requirements.

Customer interface allows Thermacore to address its customers' needs and answer any questions or concerns, typically within 24 hours. Thermacore also provides expertise on heat pipe technology and state-of-the-art thermal management to its customers. The company does not use sales pressure tactics and will not encourage heat pipe usage for non-applicable situations.

Thermacore's work ethic, dedication, and loyalty enable the company to gain the confidence of its customers. By establishing itself as a trusted expert, Thermacore is typically approached by companies for advice on thermal management and heat pipe technology. Thermacore relies on customer interface to maintain its status as an important supplier of heat pipe products.

Heat Pipe Design

All electronic components, from microprocessors to high-end power converters, generate heat. Dissipation of this heat is necessary for optimum and reliable operation of electronic components. Many of today's electronic devices require cooling beyond the capabilities of standard metallic heat sinks. Heat pipes offer a high efficiency, passive, compact heat transfer solution and are rapidly becoming a mainstream thermal management tool.

Heat pipes act as a passive heat transfer device for transferring heat from heat sources. Typically cylindrical in shape, heat pipes are sealed, evacuated vessels with a working fluid. The vessel's walls are lined with a capillary structure (wick) which allows the working fluid to travel through it. This design enables heat pipes to operate with extremely high effective thermal conductance.

As a two-phase mechanism, heat pipes are able to operate against gravity and tolerate very low temperature drops. Heat is absorbed at the hot end (evaporator) where a portion of the working fluid is changed into a vapor and travels up the center of the pipe to the cool end (condenser). As it gives off latent heat, the vapor condenses into a liquid and travels back to the evaporator through the wick. This closed-loop, two-phase mechanism allows heat pipes to transfer heat at one hundred to several thousand times the capability of an equivalent-size piece of solid copper. The heat pipe's construction and operation are illustrated in Figure 2-1.

Commercially available since the 1960s, heat pipes did not flourish in usage until the electronics industry started using them as reliable, cost-effective thermal management tools. The basic heat pipe design is well known and can be found in numerous technical publications. However, Thermacore improved upon this design through advanced development of envelope materials, working fluids, wicks, and processing techniques. As a result, Thermacore now excels in the electronics application of heat pipes, and has been recognized as a leader in heat pipe research and development through various avenues (e.g., Small Business Innovative Research grants; government and commercial contracts; heat pipe designs with the highest heat capacity).

Heat pipes contain no moving parts and have demonstrated long life and reliability. Thermacore maintains one of the world's largest and longest life testing programs. Among those being tested are copper/water (envelope/fluid) heat pipes which have been continuously running for more than 15 years with negligible changes in performance. Copper/water heat pipes are able to tolerate storage temperatures between -65°C and 250°C, and can effectively operate between 10°C and 250°C. In volume, heat pipes are competitively priced with alternate cooling technologies.

Thermacore has become an innovative leader in heat pipe technology. Through its development of sintered powder metal wick technology, Thermacore provides its customers with a highly efficient and cost-effective tool for cooling critical electronic components.

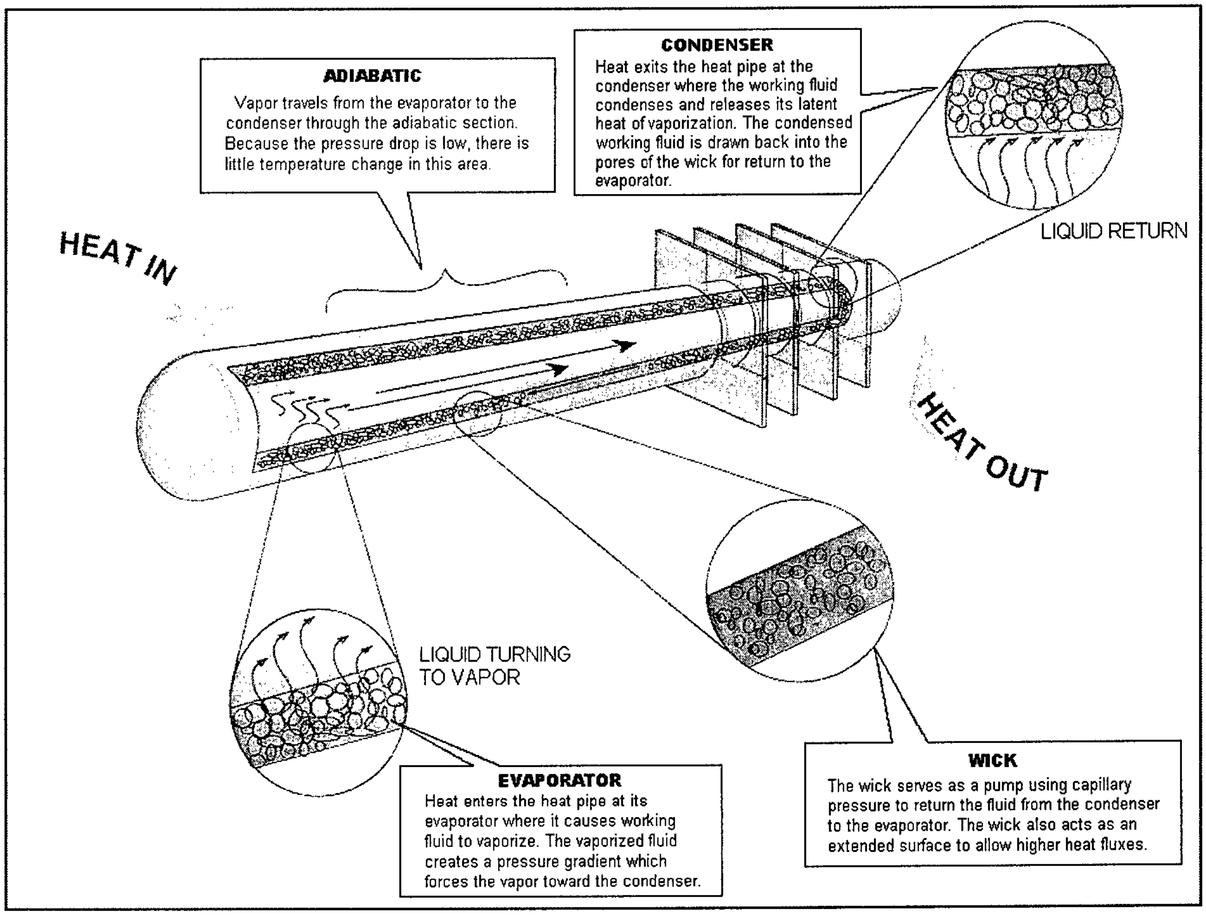


Figure 2-1. Heat Pipe Operation

Heat Pipe Wick Structure

The heat pipe's wick structure uses capillary pressure to pump the working fluid from the condenser to the evaporator. Typically, the restricting factor of heat pipe designs is the capillary limit, which is determined by the pumping capacity of the wick structure. The capillary limit is also a function of the heat pipe's operating orientation and wick structure (e.g., groove, screen, cable/fiber, sintered powder metal). Pore radius and permeability are the two most important characteristics of a wick structure. Pore radius determines the pumping pressure that the wick can develop, while permeability determines the fractional losses of the working fluid as it flows through the wick.

It is important to select the proper wick structure based on the application. Thermacore has determined that sintered powder metal is the optimum wick structure for cooling electronic components in computer products (e.g., notebooks, laptops, desktops, high-end servers). Sintered powder metal wicks have small pore radii and relatively low permeability. The high capillary pumping pressure, achieved through a sintered powder metal wick, allows the heat pipe to operate in any orientation. Other wick structures do not work as well in non-horizontal orientations because they cannot lift the returning working fluid the length of the heat pipe against gravity.

By developing specialized equipment and processes, Thermacore can vary the physical properties of its sintered powder metal wicks, allowing the heat pipes to be custom designed to the customer's application. In addition, the heat pipes can be bent to fit various heat sink shapes without any significant reduction in performance. Through its unique heat pipe technology, Thermacore has become a major supplier in the electronics industry.

Production

Material Tracking High Volume Line

In April 1996, Thermacore developed a disciplined process for tracking in-process work, scrap rates, and finished products on its high volume manufacturing lines. Prior to this, the company had no well-defined method for tracking defects or controlling manufacturing processes. Scrap rates were running at 25% to 30%.

Initially, Thermacore was a research and development company with low production volume. Demand for Thermacore's products, from the computer industry, occurred within a short period of time, and then grew very rapidly from 2,500 units per month (June 1995) to 10,000 units per day (October 1996). The company had to develop a high yield, high volume, round-the-clock manufacturing capability to meet its customers' requirements. Since heat pipes manufactured by Thermacore perform such a critical function, it is essential that 100% of the units shipped are defect free. Competitive pressures by foreign manufacturers also forced Thermacore to cut its high scrap rates in order to be cost competitive.

Many of Thermacore's manufacturing processes require some decision making by production personnel. Therefore, the material tracking system needed to do more than just control the product from raw materials to a finished unit. The system needed to handle controlled quantities, evaluate performance throughout the manufacturing process, and track products back to individual processes. Above all, the tracking system had to ensure that Thermacore's customers always receive defect-free products.

The new tracking system is designed to eliminate bottlenecks and identify problem areas. Raw materials are typically issued in lot quantities of 5,000 pieces. Each lot is broken down into smaller bin quantities of 600 pieces per bin. Bins are assigned a number and issued a material traveler. Manufacturing processes are broken into single operations. All operations have start, scrap, and finish quantities, as well as a completion date and operator initials. Each operation is entered into a computer database and tracked using bar codes and keyboard entries. Scrap quantities and scrap costs are calculated daily. All key management personnel are given a daily printout of the production quantities and scrap costs.

Thermacore's tracking system has reduced the scrap rate from 30% to less than 1%. Problems can now be identified and quickly fixed. The tracking system can recognize many simple problems that were previously overlooked, but easily correctable. The system can also track problems to a root cause (e.g., operator, process, machine, tool). The improvement in yield has kept Thermacore's products cost competitive on the world market.

Thermacore continues to improve its manufacturing processes and tracking system. Manufacturing processes are being automated to the maximum possible extent. Production personnel receive training whenever manufacturing processes are modified. Computers are playing an increasingly larger role in automating and controlling Thermacore's processes. The company is incorporating log in/log out stations into its processing areas. All information will be entered by either touch screen input or bar code scanning, eliminating keyboard usage. This improvement will further reduce data entry errors. Thermacore has also purchased a quality assurance/data acquisition program which is currently being put on line. All Final Test operations are being added to this database. Eventually, all operations will feed this system via scanning devices and an RS485 data bus.

Management

International Competitiveness

Although Thermacore started product operations in 1981, most of the company's focus was on research and development through the early 1990s. In 1993, increasing inquiries from electronic companies alerted Thermacore to the possibility that new chips, being developed by the semiconductor companies, might require the unique cooling properties of heat pipes. Intel Corporation recognized the superior thermal performance of Thermacore's sintered powder metal wick technology and designs, and passed this information on to its customers. As a result, computer manufacturers all over the world became greatly interested in Thermacore's products for Pentium chip cooling applications. At about the same time, improvements in high power transistors led to an increased need in heat pipes for cooling the large devices that control the power flow to large electric motors in rail locomotives and stationary installations (e.g., steel rolling mills).

Thermacore recognized these market opportunities and proceeded quickly to capitalize on them. The company adopted a policy and philosophy that it would never turn down an order for lack of capacity. In short order, Thermacore raised the necessary funds through a venture capital investment. The company built a factory and designed its products, manufacturing processes, and equipment. Orders began pouring in, particularly for notebook-based computer applications. Production increased from 2,500 units per month in June 1995 to 10,000 units per day by October 1996. As production rates increased, Thermacore refined its processes and methods so that scrap rates, which were initially nearly 30%, are now well under 1%. Thermacore's commitment to quality and never shipping a defective device is so strong that most of the company's customers do not even perform an incoming inspection.

From the start of this great production surge, Thermacore was an international competitor. One of the primary uses of Thermacore's products is in laptop computers, and more than 40% of the world's laptop computers are manufactured in Taiwan. Thermacore has steadily been taking market share from its competitors and has captured more than half of the heat pipe market in Taiwan. The company's market share continues to grow due in part to several factors. First is the technological edge on the competition that Thermacore has built up over its long history as a government research and development contractor. This edge is maintained primarily by the fact that the company designs and develops its own manufacturing processes and production equipment, and can continually refine and control these manufacturing processes to a high degree. Second is its commitment to quality and meeting customer requirements, no matter how demanding. Each customer's product and application is unique. The ability to be flexible and respond quickly to production ramp-ups with 100% quality help make Thermacore a leader in the market. Another factor is cost competitiveness. Thermacore's products are directly cost competitive with its Japanese and Taiwanese competitors. The company has even been successful in capturing business from Japanese competitors who sell to Japanese companies.

Thermacore's success demonstrates how a small, high tech, U.S. company can be an effective global competitor by maintaining a strong emphasis on technology, and applying it to meet market-driven needs. Management facilitated the adoption of a culture which supports rapid growth and continuous improvements in productivity and quality. These qualities have given Thermacore the capability to respond rapidly to market forces with products that its customers can depend on for superior performance at competitive prices.

Sharing the Wealth

Considered to be the most important asset, Thermacore's employees represent the key to the company's performance and competitiveness. Thermacore's success in transforming from a low volume, research and development enterprise to a high volume, production facility and technology leader has primarily occurred because of the dedication and commitment of its employees. To enable employees to participate in and benefit from the company's strong growth and performance in recent years, Thermacore has developed excellent bonus and employee stock purchase programs.

The annual employee bonus is a very effective way to let employees share in the wealth generated by operations during the year. All employees of Thermacore and its parent corporation, DTX, are eligible for the bonus program. The most unique aspect of the program is that all employees receive the same amount of bonus regardless of total compensation, seniority, or position in the company. Although Thermacore provides other methods for rewarding and recognizing performance, the bonus program affects all employees and has proven to be a very effective incentive.

The bonus pool is based on pre-federal tax income minus a minimum, threshold guarantee to the stockholders. The threshold guarantee is typically 15% of equity at the beginning of the year. The income subject to the bonus pool is multiplied by an employee bonus pool rate determined by the Board of Directors and senior management. Last year, the bonus pool rate was 12%. The number of eligible employees is an equivalent, determined number based on regular hours worked, excluding overtime and including full-year, regular hours plus part-time, disability, and lay-off hours as a percentage of regular hours. The total hours are added to give a total equivalent number of employees used for calculating the full share bonus rate. The full share bonus rate is calculated simply by dividing the bonus pool amount by the equivalent number of employees. Full-year, regular employees receive a full share, and part-time employees receive a share based on the percentage of time worked compared to full-year, regular employees. Last year, the full bonus share was more than $1,300 per employee.

Thermacore also has a stock ownership plan open to all employees. Each year, the stockholders and the Board of Directors approve a gross dollar value to be offered to active employees of the company. For example, the Board may decide to increase the equity in the company by $100,000. A subscription period (normally one month) is announced for purchase of stock at a price per share set by the Board. No one employee may subscribe for more than $10,000 worth of stock. Thermacore is a private company so stock is only traded within the company. Shares are sold to the employees at a small discount, in consideration for the company receiving the right-of-first refusal should the employee wish to leave the company or sell stock. Payment may be made in cash at the closing of the subscription period or by payroll deduction.

Thermacore's programs provide effective ways to reward all employees for the growth and profitability of the company and to acquire equity. These programs are an effective incentive and means of sharing the wealth.

Technology Support

The startling growth experienced by Thermacore in just a couple of years would seem, at first glance, to be the story of a company achieving overnight success. Most of this growth resulted from the market created by the increased power dissipation requirements of Intel Corporation's Pentium chip for notebook computers. This market turned out to be a perfect match for Thermacore's heat pipe technology. However, development of this technology did not happen overnight. As an outgrowth of more than 30 years of engineering development, Thermacore created a superior product which surpassed other available options in the marketplace. This solid technology base is the cornerstone and foundation of Thermacore's competitive edge.

The company was founded in 1970 as an engineering development company. Its founders were working at RCA in the early 1960s on high temperature heat pipe applications for cooling nuclear reactors. This work led to the development of a whole new technology for heat pipes which covered a wide range of temperature regimes and used a variety of envelope materials and fluid media. Thermacore took over this development as RCA got out of the business in the early 1970s. Initially, the work was supported by a few government contracts. In the early 1980s, the company began receiving Small Business Innovative Research grants to develop and commercialize its technology. The company also began doing research and development work for some of the large aerospace firms. By the late 1980s, the company had begun developing designs using copper tubes and sintered copper powder wicks that provided thermal power dissipation characteristics an order of magnitude beyond those achieved by earlier designs. Increasingly, customers began turning to Thermacore for specific cooling applications and assistance in solving difficult design problems. Thermacore began developing products to meet specific customer needs by drawing on its strong engineering and technology base.

By the early 1990s, the company was developing a manufacturing base, but continued to maintain a strong research and development emphasis. Throughout the history of the company, Thermacore has maintained a policy of investing 10% of its sales revenues back into engineering. Every job price includes a 10% charge for internal research and development. This strategy is important because most sales are made by educating the customer in regard to the engineering and cost advantages of heat pipe technology and by solving tough engineering problems for the customer. Most sales are made on an engineer-to-engineer basis. This requires a heavy investment in engineering and product development for each customer, but Thermacore has found that it pays off in customer loyalty, trust, and repeat business. An Applications Engineering group works closely with customers to ensure that their requirements are met.

Exploding demand for heat pipe technology applications in recent years has ushered Thermacore into an environment of high volume manufacturing and brought about many changes in the company. However, the company still maintains its strong commitment to technology, and sees this as the key to gaining an ever-increasing market share for its products on the world market. The company is maintaining its 10% investment in internal research and development, and is creating joint sales/application engineering teams comprised of engineering and sales personnel who work closely with customers to meet their needs and develop customized design solutions. Teams are currently in place for mobile computers, high-end computers, telecommunications, and traction market applications. Increases in full-time, advanced-development personnel are planned over the next two years. Thermacore has set a goal of developing two new products and entering two new market areas each year.

Section 3
Information

Production

Forward Thinking Manufacturing

Thermacore is transitioning from a small-volume, batch manufacturer to a high-volume, production facility. Presently, the company produces a wide variety of products in varying volumes. Typical product life cycles range from six months to six years. However, recent interest in the marketplace has encouraged Thermacore to apply forward thinking techniques to its manufacturing operations. The company is now focusing on quick responses to market demands, and striving to improve quality and reduce cost. A master plan has also been developed which enables the company to maintain its flexibility and meet its internal growth goals.

A key element of Thermacore's forward thinking strategy is the development of functional teams. Each team consists of research and development, application engineering, and sales personnel. The team works with customers to solve their thermal management problems, has the freedom to expand and fill any necessary voids in the product line, and is authorized to make decisions for completing the project. Based on Thermacore's overall goals and objectives, the team reviews market requirements, and methodically applies the company's products and expertise in that direction.

Thermacore's forward thinking philosophy has been very effective for its manufacturing operations. Since implementing this approach, Thermacore has reduced the cost and improved the quality of its products by many orders of magnitude. Additionally, forward thinking techniques have allowed the company to accommodate overnight orders, improve its response time to customers, and increase employee enthusiasm, which enable Thermacore to be a major competitor in the heat pipe technology and thermal management markets.

Management

Family Atmosphere

Thermacore promotes a family atmosphere in which people are considered valuable assets for sustaining a high level of commitment between the company and its employees. The company has adopted various practices which support and encourage this approach. One of these is the fast payroll cycle. The company's pay dates are the next business day after the 15th and the next business day after the end of the month. Pay records and checks are processed in-house by the administrative and accounting personnel. Time records are submitted by 8:30 A.M. on pay day. Dedicated staff has the payroll completed and ready for distribution by early afternoon. This process provides employees with prompt payment for work done; gives the company timely and current accounting information; and offers a more personal approach than using an outside vendor for payroll.

Thermacore's basic approach to maintaining a family atmosphere is to keep the work environment informal, and eliminate potential barriers between employees. Friday is designated as "dress down" day where everyone can wear casual clothing. Additionally, engineers and factory floor personnel can dress casually every day except on visitor days. The company has only one lunch/breakroom in the plant which provides a convenient place for all employees to mingle and interact. Leaders and managers make a point to frequent this area, as well as the work areas, so they can interact and communicate with employees. Thermacore also frequently sponsors special events such as holiday parties, summer outings, impromptu pizza lunches, and other activities. The overall attitude in the facility is one of sharing, caring, and smiling.

Recognizing that people are its most important asset, Thermacore takes great care to configure the company around individuals in numerous ways. Praise for jobs well done is freely given, and management seeks to recognize good performance. Communication is promoted and encouraged at all levels. Employees are motivated to voice their opinion because they know Thermacore values their ideas. In addition, employees are urged to work as much as necessary and, in return, receive liberal flexibility by the company for structuring their schedules. Although no formal suggestion program exists, employees can initiate an improvement project by obtaining approvals, soliciting funding, and implementing their ideas.

Sales Forecasting

Thermacore has developed a sales forecasting system to manage its business and production processes. Sales are broken down into seven product areas: processor modules; notebook PCs; desktop PCs; workstations/servers; telecommunications; power electronics; and other. The company then identifies its current and potential heat pipe customers for each product area.

The Three-Year Forecast chart provides information on the previous year's sales; the current year's actual and projected sales; and the next three years' forecasted sales. Current, projected, and potential customers are listed on this forecast chart. The visibility of the potential customer list enables Thermacore to identify new business opportunities and determine the additional efforts needed to obtain these new customers. The Current Business Unit Forecast chart displays the current year's forecast as well as the previous year's sales by customer.

Other charts used by Thermacore provide monthly and weekly breakdowns. The Strategic Design Wins chart shows designs won, designs pending, new prospects, and designs lost per month. This chart provides instant visibility for identifying those projects which are critical for Thermacore's future business success. The Forecast vs. Plan chart compares the company's operating plan with its monthly forecast, and highlights the variations between the two. Thermacore also developed a Master Schedule chart for its production area, which shows the previous two weeks' history, the current month's weekly production requirements, the next three months' weekly production requirements; and the projected demand for the following six months.

Thermacore uses its business forecasts in a weekly, future-business meeting to discuss strategies and actions for winning future business. The production schedule is used in a different weekly meeting to discuss production problems and other issues. These meetings are key tools that enable Thermacore to meet its delivery schedules and attain future work.

Many of Thermacore's customers developed from a long-term working relationship which did not have an immediate pay off in new business. Thermacore routinely assists potential customers with their thermal problems without gaining immediate sales. One customer, who has just begun buying large quantities of heat pipes, had been working with Thermacore for the past three years on thermal transfer problems. This willingness to work with potential customers and provide them with the best possible solution for their situation has resulted in many loyal and dedicated customers of Thermacore. Upon placing an order, customers can rely on Thermacore's dedicated workforce to deliver prompt, quality products.

Appendix A
Table of Acronyms

No Acronyms were used in this survey report.

Appendix B

BMP Survey Team

Team Member	Activity	Function
Larry Robertson (812) 854-5336	**Crane Division** **Naval Surface Warfare Center** Crane, IN	**Team Chairman**
Cheri Spencer (301) 403-8100	**BMP Center of Excellence** College Park, MD	**Technical Writer**

Team

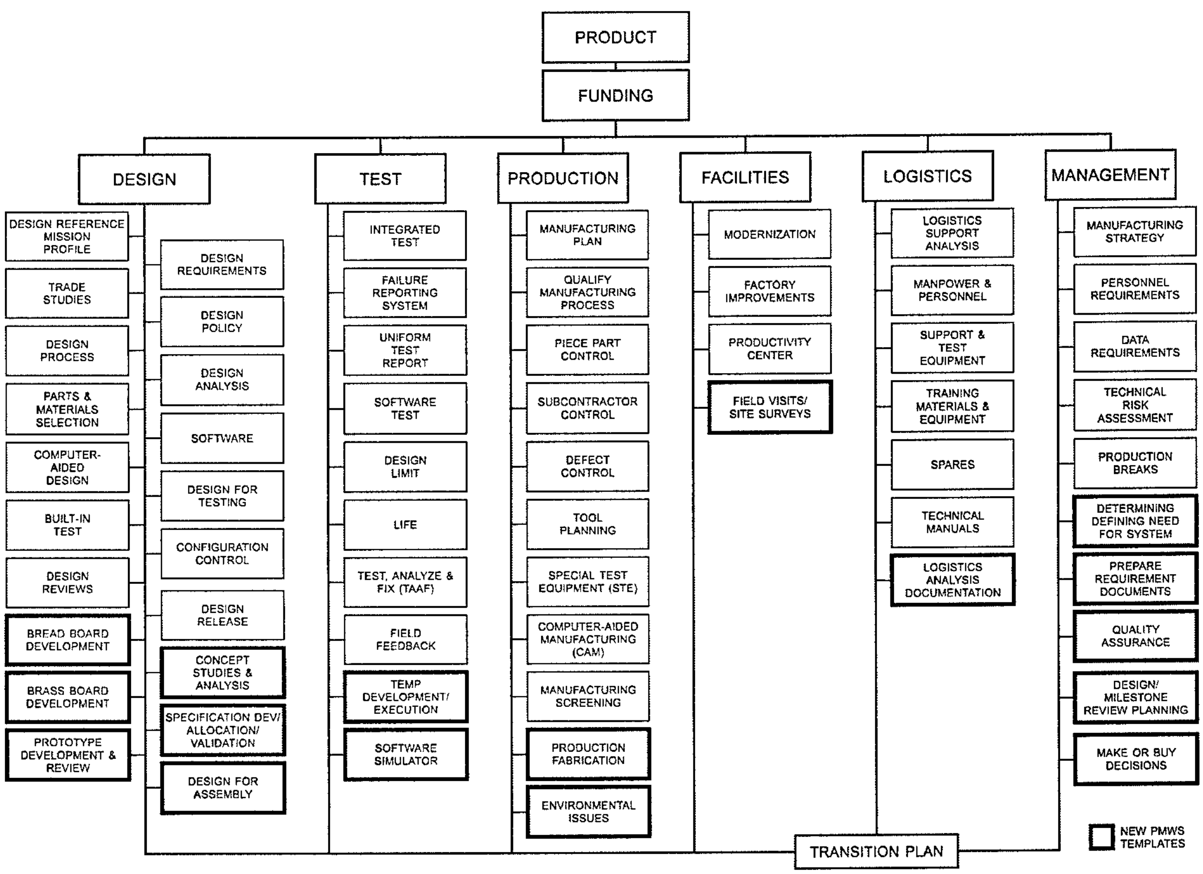
Rick Purcell (301) 403-8100	**BMP Center of Excellence** College Park, MD	**Team Leader**
Nick Keller (812) 854-5331	**Naval Surface Warfare Center** Crane, IN	

Appendix C
Critical Path Templates and BMP Templates

This survey was structured around and concentrated on the functional areas of design, test, production, facilities, logistics, and management as presented in the Department of Defense 4245.7-M, *Transition from Development to Production* document. This publication defines the proper tools—or templates—that constitute the critical path for a successful material acquisition program. It describes techniques for improving the acquisition process by addressing it as an *industrial* process that focuses on the product's design, test, and production phases which are interrelated and interdependent disciplines.

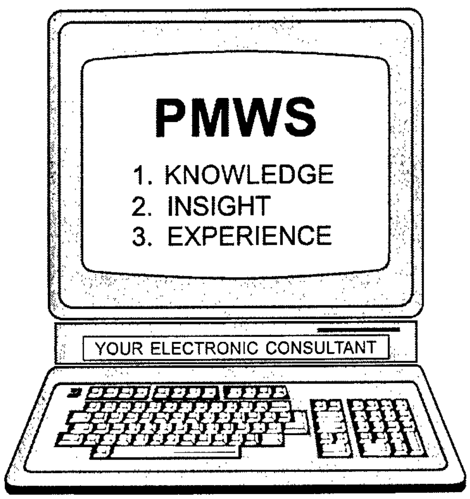
The BMP program has continued to build on this knowledge base by developing 17 new templates that complement the existing DOD 4245.7-M templates. These BMP templates address new or emerging technologies and processes.

"CRITICAL PATH TEMPLATES FOR TRANSITION FROM DEVELOPMENT TO PRODUCTION"



Appendix D
BMPnet and the Program Manager's WorkStation

The BMPnet, located at the Best Manufacturing Practices Center of Excellence (BMPCOE) in College Park, Maryland, supports several communication features. These features include the Program Manager's WorkStation (**PMWS**), electronic mail and file transfer capabilities, as well as access to Special Interest Groups (SIGs) for specific topic information and communication. The BMPnet can be accessed through the World Wide Web (at http://www.bmpcoe.org), through free software that connects directly over the Internet or through a modem. The PMWS software is also available on CD-ROM.



PMWS provides users with timely acquisition and engineering information through a series of interrelated software environments and knowledge-based packages. The main components of PMWS are KnowHow, SpecRite, the Technical Risk Identification and Mitigation System (TRIMS), and the BMP Database.

KnowHow is an intelligent, automated program that provides rapid access to information through an intelligent search capability. Information currently available in KnowHow handbooks includes Acquisition Streamlining, Non-Development Items, Value Engineering, NAVSO P-6071 (Best Practices Manual), MIL-STD-2167/2168 and the DoD 5000 series documents. KnowHow cuts document search time by 95%, providing critical, user-specific information in under three minutes.

SpecRite is a performance specification generator based on expert knowledge from all uniformed services. This program guides acquisition personnel in creating specifications for their requirements, and is structured for the build/approval process. SpecRite's knowledge-based guidance and assistance structure is modular, flexible, and provides output in MIL-STD 961D format in the form of editable WordPerfect® files.

TRIMS, based on DoD 4245.7-M (the transition templates), NAVSO P-6071, and DoD 5000 event-oriented acquisition, helps the user identify and rank a program's high-risk areas. By helping the user conduct a full range of risk assessments throughout the acquisition process, TRIMS highlights areas where corrective action can be initiated before risks develop into problems. It also helps users track key project documentation from concept through production including goals, responsible personnel, and next action dates for future activities.

The **BMP Database** contains proven best practices from industry, government, and the academic communities. These best practices are in the areas of design, test, production, facilities, management, and logistics. Each practice has been observed, verified, and documented by a team of government experts during BMP surveys.

Access to the BMPnet through dial-in or on Internet requires a special modem program. This program can be obtained by calling the BMPnet Help Desk at (301) 403-8179 or it can be downloaded from the World Wide Web at http://www.bmpcoe.org. To receive a user/e-mail account on the BMPnet, send a request to helpdesk@bmpcoe.org.

Appendix E
Best Manufacturing Practices Satellite Centers

There are currently six Best Manufacturing Practices (BMP) satellite centers that provide representation for and awareness of the BMP program to regional industry, government and academic institutions. The centers also promote the use of BMP with regional Manufacturing Technology Centers. Regional manufacturers can take advantage of the BMP satellite centers to help resolve problems, as the centers host informative, one-day regional workshops that focus on specific technical issues.

Center representatives also conduct BMP lectures at regional colleges and universities; maintain lists of experts who are potential survey team members; provide team member training; identify regional experts for inclusion in the BMPnet SIG e-mail; and train regional personnel in the use of BMP resources such as the BMPnet.

The six BMP satellite centers include:

California

Chris Matzke
BMP Satellite Center Manager
Naval Warfare Assessment Division
Code QA-21, P.O. Box 5000
Corona, CA 91718-5000
(909) 273-4992
FAX: (909) 273-4123
cmatzke@bmpcoe.org

Jack Tamargo
BMP Satellite Center Manager
257 Cottonwood Drive
Vallejo, CA 94591
(707) 642-4267
FAX: (707) 642-4267
jtamargo@bmpcoe.org

District of Columbia

Margaret Cahill
BMP Satellite Center Manager
U.S. Department of Commerce
14th Street & Constitution Avenue, NW
Room 3876 BXA
Washington, DC 20230
(202) 482-8226/3795
FAX: (202) 482-5650
mcahill@bxa.doc.gov

Illinois

Thomas Clark
BMP Satellite Center Manager
Rock Valley College
3301 North Mulford Road
Rockford, IL 61114
(815) 654-5515
FAX: (815) 654-4459
adme3tc@rvcux1.rvc.cc.il.us

Pennsylvania

Sherrie Snyder
BMP Satellite Center Manager
MANTEC, Inc.
P.O. Box 5046
York, PA 17405
(717) 843-5054, ext. 225
FAX: (717) 854-0087
snyderss@mantec.org

Tennessee

Tammy Graham
BMP Satellite Center Manager
Lockheed Martin Energy Systems
P.O. Box 2009, Bldg. 9737
M/S 8091
Oak Ridge, TN 37831-8091
(423) 576-5532
FAX: (423) 574-2000
tgraham@bmpcoe.org

Appendix F

Navy Manufacturing Technology Centers of Excellence

The Navy Manufacturing Sciences and Technology Program established the following Centers of Excellence (COEs) to provide focal points for the development and technology transfer of new manufacturing processes and equipment in a cooperative environment with industry, academia, and Navy centers and laboratories. These COEs are consortium-structured for industry, academia, and government involvement in developing and implementing technologies. Each COE has a designated point of contact listed below with the individual COE information.

Best Manufacturing Practices Center of Excellence

The Best Manufacturing Practices Center of Excellence (BMPCOE) provides a national resource to identify and promote exemplary manufacturing and business practices and to disseminate this information to the U.S. Industrial Base. The BMPCOE was established by the Navy's BMP program, Department of Commerce's National Institute of Standards and Technology, and the University of Maryland at College Park, Maryland. The BMPCOE improves the use of existing technology, promotes the introduction of improved technologies, and provides non-competitive means to address common problems, and has become a significant factor in countering foreign competition.

Point of Contact:
Mr. Ernie Renner
Best Manufacturing Practices Center of Excellence
4321 Hartwick Road
Suite 400
College Park, MD 20740
(301) 403-8100
FAX: (301) 403-8180
ernie@bmpcoe.org

Center of Excellence for Composites Manufacturing Technology

The Center of Excellence for Composites Manufacturing Technology (CECMT) provides a national resource for the development and dissemination of composites manufacturing technology to defense contractors and subcontractors. The CECMT is managed by the GreatLakes Composites Consortium and represents a collaborative effort among industry, academia, and government to develop, evaluate, demonstrate, and test composites manufacturing technologies. The technical work is problem-driven to reflect current and future Navy needs in the composites industrial community.

Point of Contact:
Dr. Roger Fountain
Center of Excellence for Composites Manufacturing Technology
103 Trade Zone Drive
Suite 26C
West Columbia, SC 29170
(803) 822-3705
FAX: (803) 822-3730
rfglcc@glcc.org

Electronics Manufacturing Productivity Facility

The Electronics Manufacturing Productivity Facility (EMPF) identifies, develops, and transfers innovative electronics manufacturing processes to domestic firms in support of the manufacture of affordable military systems. The EMPF operates as a consortium comprised of industry, university, and government participants, led by the American Competitiveness Institute under a CRADA with the Navy.

Point of Contact:
Mr. Alan Criswell
Electronics Manufacturing Productivity Facility
Plymouth Executive Campus
Bldg 630, Suite 100
630 West Germantown Pike
Plymouth Meeting, PA 19462
(610) 832-8800
FAX: (610) 832-8810
http://www.engriupui.edu/empf/

National Center for Excellence in Metalworking Technology

The National Center for Excellence in Metalworking Technology (NCEMT) provides a national center for the development, dissemination, and implementation of advanced technologies for metalworking products and processes. The NCEMT, operated by Concurrent Technologies Corporation, helps the Navy and defense contractors improve

manufacturing productivity and part reliability through development, deployment, training, and education for advanced metalworking technologies.

Point of Contact:
Mr. Richard Henry
National Center for Excellence in Metalworking Technology
1450 Scalp Avenue
Johnstown, PA 15904-3374
(814) 269-2532
FAX: (814) 269-2799
henry@ctc.com

Navy Joining Center

The Navy Joining Center (NJC) is operated by the Edison Welding Institute and provides a national resource for the development of materials joining expertise and the deployment of emerging manufacturing technologies to Navy contractors, subcontractors, and other activities. The NJC works with the Navy to determine and evaluate joining technology requirements and conduct technology development and deployment projects to address these issues.

Point of Contact:
Mr. David P. Edmonds
Navy Joining Center
1100 Kinnear Road
Columbus, OH 43212-1161
(614) 487-5825
FAX: (614) 486-9528
dave_edmonds@ewi.org

Energetics Manufacturing Technology Center

The Energetics Manufacturing Technology Center (EMTC) addresses unique manufacturing processes and problems of the energetics industrial base to ensure the availability of affordable, quality energetics. The focus of the EMTC is on process technology with a goal of reducing manufacturing costs while improving product quality and reliability. The COE also maintains a goal of development and implementation of environmentally benign energetics manufacturing processes.

Point of Contact:
Mr. John Brough
Energetics Manufacturing Technology Center
Indian Head Division
Naval Surface Warfare Center
Indian Head, MD 20640-5035
(301) 743-4417
DSN: 354-4417
FAX: (301) 743-4187
mt@command.nosih.sea06.navy.mil

Manufacturing Science and Advanced Materials Processing Institute

The Manufacturing Science and Advanced Materials Processing Institute (MS&AMPI) is comprised of three centers including the National Center for Advanced Drivetrain Technologies (NCADT), The Surface Engineering Manufacturing Technology Center (SEMTC), and the Laser Applications Research Center (LaserARC). These centers are located at The Pennsylvania State University's Applied Research Laboratory. Each center is highlighted below.

Point of Contact for MS&AMPI:
Mr. Henry Watson
Manufacturing Science and Advanced Materials Processing Institute
ARL Penn State
P.O. Box 30
State College, PA 16804-0030
(814) 865-6345
FAX: (814) 863-1183
hew2@psu.edu

- **National Center for Advanced Drivetrain Technologies**

  The NCADT supports DoD by strengthening, revitalizing, and enhancing the technological capabilities of the U.S. gear and transmission industry. It provides a site for neutral testing to verify accuracy and performance of gear and transmission components.

  Point of Contact for NCADT:
  Dr. Suren Rao
  NCADT/Drivetrain Center
  ARL Penn State
  P.O. Box 30
  State College, PA 16804-0030
  (814) 865-3537
  FAX: (814) 863-6185
  http://www.arl.psu.edu/drivetrain_center.html/

- **Surface Engineering Manufacturing Technology Center**

  The SEMTC enables technology development in surface engineering—the systematic and rational modification of material surfaces to provide desirable material characteristics and performance. This can be implemented for complex optical, electrical, chemical, and mechanical functions or products that affect the cost, operation, maintainability, and reliability of weapon systems.

  Point of Contact for SEMTC:
  Dr. Maurice F. Amateau
  SEMTC/Surface Engineering Center
  P.O. Box 30
  State College, PA 16804-0030
  (814) 863-4214
  FAX: (814) 863-0006
  http://www/arl.psu.edu/divisions/arl_org.html

- **Laser Applications Research Center**

  The LaserARC is established to expand the technical capabilities of DOD by providing access to high-power industrial lasers for advanced material processing applications. LaserARC offers basic and applied research in laser-material interaction, process development, sensor technologies, and corresponding demonstrations of developed applications.

  Point of Contact for LaserARC:
  Mr. Paul Denney
  Laser Center
  ARL Penn State
  P.O. Box 30
  State College, PA 16804-0030
  (814) 865-2934
  FAX: (814) 863-1183
  http://www/arl.psu.edu/divisions/arl_org.html

Gulf Coast Region Maritime Technology Center

The Gulf Coast Region Maritime Technology Center (GCRMTC) is located at the University of New Orleans and will focus primarily on product developments in support of the U.S. shipbuilding industry. A sister site at Lamar University in Orange, Texas will focus on process improvements.

Point of Contact:
Dr. John Crisp
Gulf Coast Region Maritime Technology Center
University of New Orleans
Room N-212
New Orleans, LA 70148
(504) 286-3871
FAX: (504) 286-3898

Appendix G
Completed Surveys

As of this publication, 95 surveys have been conducted and published by BMP at the companies listed below. Copies of older survey reports may be obtained through DTIC or by accessing the BMPnet. Requests for copies of recent survey reports or inquiries regarding the BMPnet may be directed to:

Best Manufacturing Practices Program
4321 Hartwick Rd., Suite 400
College Park, MD 20740
Attn: Mr. Ernie Renner, Director
Telephone: 1-800-789-4267
FAX: (301) 403-8180
ernie@bmpcoe.org

1985	Litton Guidance & Control Systems Division - Woodland Hills, CA
1986	Honeywell, Incorporated Undersea Systems Division - Hopkins, MN (Alliant TechSystems, Inc.) Texas Instruments Defense Systems & Electronics Group - Lewisville, TX General Dynamics Pomona Division - Pomona, CA Harris Corporation Government Support Systems Division - Syosset, NY IBM Corporation Federal Systems Division - Owego, NY Control Data Corporation Government Systems Division - Minneapolis, MN
1987	Hughes Aircraft Company Radar Systems Group - Los Angeles, CA ITT Avionics Division - Clifton, NJ Rockwell International Corporation Collins Defense Communications - Cedar Rapids, IA UNISYS Computer Systems Division - St. Paul, MN (Paramax)
1988	Motorola Government Electronics Group - Scottsdale, AZ General Dynamics Fort Worth Division - Fort Worth, TX Texas Instruments Defense Systems & Electronics Group - Dallas, TX Hughes Aircraft Company Missile Systems Group - Tucson, AZ Bell Helicopter Textron, Inc. - Fort Worth, TX Litton Data Systems Division - Van Nuys, CA GTE C^3 Systems Sector - Needham Heights, MA
1989	McDonnell-Douglas Corporation McDonnell Aircraft Company - St. Louis, MO Northrop Corporation Aircraft Division - Hawthorne, CA Litton Applied Technology Division - San Jose, CA Litton Amecom Division - College Park, MD Standard Industries - LaMirada, CA Engineered Circuit Research, Incorporated - Milpitas, CA Teledyne Industries Incorporated Electronics Division - Newbury Park, CA Lockheed Aeronautical Systems Company - Marietta, GA Lockheed Corporation Missile Systems Division - Sunnyvale, CA Westinghouse Electronic Systems Group - Baltimore, MD General Electric Naval & Drive Turbine Systems - Fitchburg, MA Rockwell International Corporation Autonetics Electronics Systems - Anaheim, CA TRICOR Systems, Incorporated - Elgin, IL
1990	Hughes Aircraft Company Ground Systems Group - Fullerton, CA TRW Military Electronics and Avionics Division - San Diego, CA MechTronics of Arizona, Inc. - Phoenix, AZ Boeing Aerospace & Electronics - Corinth, TX Technology Matrix Consortium - Traverse City, MI Textron Lycoming - Stratford, CT

1991	*Resurvey of Litton Guidance & Control Systems Division* - Woodland Hills, CA Norden Systems, Inc. - Norwalk, CT Naval Avionics Center - Indianapolis, IN United Electric Controls - Watertown, MA Kurt Manufacturing Co. - Minneapolis, MN MagneTek Defense Systems - Anaheim, CA Raytheon Missile Systems Division - Andover, MA AT&T Federal Systems Advanced Technologies and AT&T Bell Laboratories - Greensboro, NC and Whippany, NJ *Resurvey of Texas Instruments Defense Systems & Electronics Group* - Lewisville, TX
1992	Tandem Computers - Cupertino, CA Charleston Naval Shipyard - Charleston, SC Conax Florida Corporation - St. Petersburg, FL Texas Instruments Semiconductor Group Military Products - Midland, TX Hewlett-Packard Palo Alto Fabrication Center - Palo Alto, CA Watervliet U.S. Army Arsenal - Watervliet, NY Digital Equipment Company Enclosures Business - Westfield, MA and Maynard, MA Computing Devices International - Minneapolis, MN *(Resurvey of Control Data Corporation Government Systems Division)* Naval Aviation Depot Naval Air Station - Pensacola, FL
1993	NASA Marshall Space Flight Center - Huntsville, AL Naval Aviation Depot Naval Air Station - Jacksonville, FL Department of Energy Oak Ridge Facilities (Operated by Martin Marietta Energy Systems, Inc.) - Oak Ridge, TN McDonnell Douglas Aerospace - Huntington Beach, CA Crane Division Naval Surface Warfare Center - Crane, IN and Louisville, KY Philadelphia Naval Shipyard - Philadelphia, PA R. J. Reynolds Tobacco Company - Winston-Salem, NC Crystal Gateway Marriott Hotel - Arlington, VA Hamilton Standard Electronic Manufacturing Facility - Farmington, CT Alpha Industries, Inc. - Methuen, MA
1994	Harris Semiconductor - Melbourne, FL United Defense, L.P. Ground Systems Division - San Jose, CA Naval Undersea Warfare Center Division Keyport - Keyport, WA Mason & Hanger - Silas Mason Co., Inc. - Middletown, IA Kaiser Electronics - San Jose, CA U.S. Army Combat Systems Test Activity - Aberdeen, MD Stafford County Public Schools - Stafford County, VA
1995	Sandia National Laboratories - Albuquerque, NM Rockwell Defense Electronics Collins Avionics & Communications Division - Cedar Rapids, IA *(Resurvey of Rockwell International Corporation Collins Defense Communications)* Lockheed Martin Electronics & Missiles - Orlando, FL McDonnell Douglas Aerospace (St. Louis) - St. Louis, MO *(Resurvey of McDonnell-Douglas Corporation McDonnell Aircraft Company)* Dayton Parts, Inc. - Harrisburg, PA Wainwright Industries - St. Peters, MO Lockheed Martin Tactical Aircraft Systems - Fort Worth, TX *(Resurvey of General Dynamics Fort Worth Division)* Lockheed Martin Government Electronic Systems - Moorestown, NJ Sacramento Manufacturing and Services Division - Sacramento, CA JLG Industries, Inc. - McConnellsburg, PA
1996	City of Chattanooga - Chattanooga, TN Mason & Hanger Corporation - Pantex Plant - Amarillo, TX Nascote Industries, Inc. - Nashville, IL Weirton Steel Corporation - Weirton, WV NASA Kennedy Space Center - Cape Canaveral, FL Department of Energy, Oak Ridge Operations - Oak Ridge, TN

1997	Headquarters, U.S. Army Industrial Operations Command - Rock Island, IL SAE International and Performance Review Institute - Warrendale, PA Polaroid Corporation - Waltham, MA Cincinnati Milacron, Inc. - Cincinnati, OH Lawrence Livermore National Laboratory - Livermore, CA Sharretts Plating Company, Inc. - Emigsville, PA Thermacore, Inc. - Lancaster, PA

INTERNET DOCUMENT INFORMATION FORM

A . Report Title: Best Manufacturing Practices: Report of Survey Conducted at Thermacore, Inc., Lancaster, PA

B. DATE Report Downloaded From the Internet: 01/14/02

C. Report's Point of Contact: (Name, Organization, Address, Office Symbol, & Ph #): Best Manufacturing Practices
Center of Excellence
College Park, MD

D. Currently Applicable Classification Level: Unclassified

E. Distribution Statement A: Approved for Public Release

F. The foregoing information was compiled and provided by:
DTIC-OCA, Initials: __VM__ **Preparation Date 01/14/02**

The foregoing information should exactly correspond to the Title, Report Number, and the Date on the accompanying report document. If there are mismatches, or other questions, contact the above OCA Representative for resolution.